Engagement Activity: Journey of a PCB Molecule

This activity was adapted by the UNC Superfund Research Program from the chapter "Journey to the Ends of the Earth" in the book *Our Stolen Future*, by Theo Colborn, Dianne Dumanoski, & John Peterson Myers and from the PBS.org interactive titled *A Toxic journey* which is also based on the book.

Our Stolen Future: **http://www.ourstolenfuture.org/**
PBS.org interactive , *A Toxic journey* http://www.pbs.org/tradesecrets/pcb/toxicjflash.html

Instructions:

1. Print this document and cut each sheet in half to generate 20 brief story cards, each representing one step in a hypothetical journey of a PCB molecule from its site of synthesis in Anniston, Alabama into the blubber of a pregnant polar bear in the Arctic.
2. Distribute a card to each student in the class. Ask the student holding step #1 to read his/her step aloud to the class and then ask the next student to read step #2, etc.
3. You can project the corresponding photos (PPT slides) onto the projector to illustrate the journey.
4. Once all steps have been read conclude this activity by asking students to discuss their reaction to this journey.
5. Use this activity as a springboard to facilitate a deeper exploration of related concepts: biomagnification, industrial chemicals, etc.
6. As an extension, have students map out the location of each step in the journey on a map of North America to visually depict the journey.

1. Our imaginary PCB molecule - a chemical known among scientists as PCB-153 because of the arrangement of its chlorine atoms - set off on its global wanderings just after World War II. The Monsanto Chemical Works plant in Anniston, Alabama produced this first batch of PCB-153 in 1947, by heating iron filings with a chlorine chemical called biphenyl. Monsanto often sold the compound, which contained not only PCB-153, but dozens of other members of the large PCB family – under its brand name Aroclor-1254.

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2. PCB-153 is among the most long-lived industrial chemicals. Almost half a century later, the PCBs made on that spring day might be found virtually anywhere imaginable: in the sperm of a man tested at a fertility clinic in upstate New York, in a wheel of ripe brie cheese, in the fat of a newborn baby in Michigan, in penguins in Antarctica, in the milk of a nursing mother in France, in the Arctic polar bear.

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3. Our imaginary molecule might have made its first trip by train. A few weeks after manufacture, a freight train carrying a shipment of Aroclor-1254 rumbled over the rails in New York State headed for a plant in Pittsfield, Massachusetts where General Electric manufactured electrical transformers. These ubiquitous metal cans attached to electrical poles reduce high-voltage current from transmission lines into the lower voltage required by lights and appliances. Because PCBs did not catch fire and burn, they offered a safer alternative to the flammable oil previously used in transformers. GE blended Aroclor into its own custom formula called Pyranol.

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4. On a steamy day in June, a worker at the GE reached for a hose at his workstation that was connected through underground pipes to storage tanks. After making a final check on the transformer he had been finishing, he opened the valve and filled it to the top with Pyranol.

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5. In a few days, our molecule of PCB-153, sealed tightly inside that new transformer, was heading back south by train. The shipment of transformers arrived at an oil refinery in Big Spring, Texas in July. Within a week, the distribution transformer containing our molecule of PCB-153 was installed in a building that housed the refinery control room.

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6. Not even a month had passed before a fierce August thunderstorm tore through Big Spring, filling the air with exploding thunder and lightning that caused a power surge that hit the transformer near the control room. It responded with a metallic thump and the building went dark. The following morning, the refinery's maintenance supervisor lifted the cover of the transformer and saw twisted, crumbled coils. He decided that the unit was beyond repair, so he asked one of his men to empty the unit and send it off to the dump.

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7. As it was hauled off, it tilted and some of its oily contents oozed out onto the red dirt of the parking lot, and PCB-153 slipped into the greasy puddle. The worker thought that the oil might help keep down the insufferable dust. Since PCBs have an affinity for organic matter, the molecule quickly attached itself to a dust particle.

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8. Four months later, a winter storm roared through and swept the molecule into the air. The dust particle with PCB-153 rode the storm and finally settled in a drift on the kitchen floor of a farmhouse. When the windstorm passed, the woman of the house took up her corn-straw broom and whisked the dust particle with our itinerant molecule into a dustpan. As it fell into the wastebasket, the dust particle sifted down into a crumpled, grease-stained newspaper page that the housewife had used to drain her bacon that morning.

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9. By the end of the week, PCB-153 was buried under trash in a local dump, an informal affair in a ravine with a parched creek. Despite the rivulets that flowed down through the growing mountain of trash during summer thunderstorms, the molecule stayed put for more than two years, for unlike, many chemicals, PCBs don't dissolve readily in water.

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10. The late winter of 1948 brought a spell of heavy rains to west Texas. After intermittent downpours, the creek surged to life in the beginning of March and roared toward the trash that tumbled down the side of the ravine. The roiling waters took a bite out of one edge of the trash mound, sweeping the greasy newspaper and the molecule from the transformer spill downstream. The floodwaters subsided the following morning, leaving the soggy newspaper sheet stranded on a sandbar five miles away. PCB-153 was clinging to a greasy blotch on the page, shielded from the light but exposed to warm spring air.

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11. As the sun climbed higher and winter turned to spring, the lump of paper dried and slowly warmed. With the sun beating down on the paper in early April, PCBs suddenly began disengaging from the dust particle moving upward, floating into the air as a vapor. The PCB-153 was suddenly free. The journey that would end in the rump fat of a Norwegian polar bear had begun.

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12. A rising current of spring air pushed it higher into the atmosphere, and the molecule soared upward, higher and higher on the thermal. When the air mass collided with a cold front moving down from the north, the journey ended abruptly. The clouds released their moisture in a hard, cold rain, and PCB-153 washed back to earth and landed on a bluff overlooking the Mississippi River north of St. Louis. During three weeks of cloudy weather, the molecule clung to a rotting leaf on a rocky outcropping, but as soon as the sun reemerged and the temperature climbed, the molecule floated off again.

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13. As a cold front moved across the country, a torrent of air rushed through and swept the PCB molecule east toward the Atlantic Ocean. Like all PCBs, the molecule had a predilection for surfaces, so it lingered on the boundary between the air and water, bumping now and again into other wandering chemical molecules. At any cold spot it encountered, the molecule condensed and settled on any available surface, only to be off again as soon as the summer sun warmed the surface.

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14. Alternating between liquid and gas, it rode the winds farther and farther north. The waters grew colder, making it increasingly difficult for the molecule to become airborne. Instead it hitchhiked on one of the small floating plants at the bottom of the North Atlantic food web, sweeping into the Gulf Stream and from then on north and east toward Iceland.

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15. Two hundred miles east of Iceland, a small shrimp like creature called a copepod finally nabbed the plant and PCB-153 as it filtered a meal out of the rich waters of the North Atlantic. Five days later, a cloud of copepods was swept into a swift current that carried them north and east like a giant conveyer belt toward the edge of the solid pack ice in the Greenland Sea.

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16. There, a large school of Arctic cod had gathered to feast on the incoming bounty. The Arctic food web, which includes the cod, is quite simple, but it includes many long-lived animals that accumulate significant amounts of contamination over a lifetime. As one of the small codfish digested its stomachful of copepods, PCB-153 migrated to the fatty tissue near its tail, which already had a considerable store of persistent chemicals. Though far from a top predator, this cod carried PCBs at 48 million times the concentration found in the surrounding waters.

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17. That season, the cod carrying PCB-153 followed the shifting food supply, and on the trail of a particularly abundant crop of copepods, it gradually swam toward the eastern part of the Greenland Sea. It was only a matter of time before the cod carrying PCB-153 became a meal for a hungry adolescent seal that shot through the water, propelled by its powerful hind flippers. A seal eats hundreds of fish, ingesting and storing all the PCBs that had accumulated in them. For this reason, the PCB levels in the seals are eight times greater than in the cod, or 384 million times the concentrations in the ocean water.

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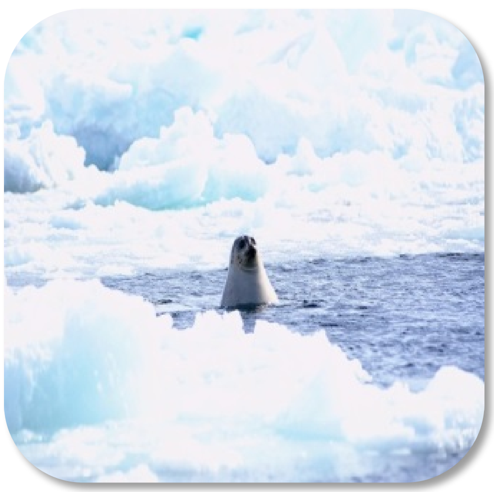

18. Once the sea closes over with ice, the seals breathe through holes that they keep open by punching through at regular intervals with their noses. The great white bears can sniff out these holes from a remarkable distance, and they often hunt by waiting in ambush. The young seal had just surfaced to breathe when a polar bear lunged out and, in a single continuous movement, flipped the 150-pound animal out of the water and onto the ice. The ringed seal died instantly in the attack by the five-year-old female bear.

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19. In thirty minutes, the polar bear had consumed the best parts of the seal-- its skin and succulent blubber-- and acquired PCB-153 along with a considerable synthetic chemical legacy. The bear was quickly gaining weight because of the good hunting, so as she laid on more fat the molecule moved into her well-insulated rump. In late April, the young female mated for the first time, and the next winter, gave birth to two tiny pink cubs. As mother and cubs nestled in their den, the cubs found their way to her nipples and began nursing on her rich, fatty milk. Throughout the winter, the mother and cubs all lived on the ample layers of fat she had laid down the previous year.

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20. As the fat melted away, PCB-153 was on the move again, this time into the breast milk of the female bear. The twin cubs would continue to nurse for more than two years and to grow to roughly four hundred pounds each on the rich diet of polar bear milk. With each meal, they would take in more of the persistent chemicals that had traveled thousands of miles to the remote Arctic. The concentrations of PCBs had multiplied 3 billion times as they moved up the Arctic food chain to the polar bear, the top predator and largest land carnivore.

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